# Navigation and Ancillary Information Facility Services

**February, 2002 C. Acton**

NASA's Navigation and Ancillary Information Facility (NAIF) is responsible for design and implementation of the SPICE ancillary information system described below. The SPICE system can be used to assist PI teams in mission design, mission planning, observation planning, and interpretation of scientific observations. SPICE helps the Mars Scout Team work in concert with Mission Operations Services. It does not compete with nor replace those components.

SPICE data sets--or inputs needed to make SPICE data sets--are generally produced by a number of project organizations, such as Mission Design, Navigation, Spacecraft Engineering, Sequencing, the vehicle prime contractor, instrument builders, and the NAIF itself. Exactly which groups do which jobs is arranged on a case-by-case basis. Proposal writers are strongly encouraged to contact the NAIF organization, whether directly or through a participating partner, to discuss available options.

The primary SPICE data sets, called “kernels” or "kernel files," contain a fundamental set of ancillary information of interest to scientists and engineers. SPICE kernel contents are summarized below:

**S** **S**pacecraft ephemeris; or, more generally, location of an observer, given as a function of time.

**P** **P**lanet, satellite, comet, or asteroid ephemeredes; or, more generally, location of a target, given as a function of time.

The **P** kernel also includes certain physical, dynamical, and cartographic constants for target bodies, such as size and shape specifications, and orientation of the spin axis and prime meridian.

**I** **I**nstrument description kernel, containing descriptive and operational data peculiar to a particular scientific instrument, most especially field-of-view size, shape, and orientation parameters.

**C** Pointing kernel, containing a transformation (historically called the **C**-matrix), which yields time-tagged pointing (orientation) angles for a spacecraft structure upon which science instruments are mounted. C-kernels may also be made to describe the time-varying orientation of articulating structures such as a steerable high-gain antenna or a movable mirror within an instrument.

**E** **E**vents kernel, the principal contents of which are derived from the integrated sequence of events used to produce actual spacecraft commands. Also part of the Events kernel is an electronic Experimenter's Notebook.

Several additional kernels are also part of SPICE:

Spacecraft clock coefficients (SCLK) and leapseconds (LSK) are used in converting time tags between various time measurement systems.

Frame specifications (FK) provide rules for establishing the relationship of the various reference frames (“coordinate systems”) used on a particular mission. These rules greatly simplify (automate) fulfilling user requests for transformations of location and pointing information between reference frames.

The SPICE system includes subroutines needed to read the kernel files and calculate most common observation geometry parameters. Users integrate these "SPICE Toolkit” subroutines into their own application programs to compute observation geometry parameters and related information when and where needed. Extensive software documentation and examples are provided with the Toolkit. The Toolkit also includes some subroutines used in writing SPICE kernels.

The SPICE Toolkit software was originally written in FORTRAN but is now available in C as well. This software is portable to any computer platform that supports ANSI FORTRAN 77 or ANSI C. These subroutines may also be accessed from other languages on most platforms.

A set of Interactive Data Language (C) “wrappers” is also available, providing a “natural feeling” interface to SPICE from within that popular programming environment.

The full family of SPICE kernel file types is easily ported between heterogeneous platforms, either as ASCII (text) files, or using built-in run-time binary translation, or using utility programs contained in the SPICE Toolkit.

“Predict” SPICE kernel files may be generated for mission planning and observation design purposes. “Actual” or "reconstruction" SPICE kernel files––based on processed telemetry--are produced during flight operations to support detailed science data analyses. Both flavors of SPICE kernels are also often used in mission engineering tasks, such as telecomm and thermal analysis.

While most SPICE kernel files are usually produced by the mission operations elements supporting the PI, the PI may also produce SPICE kernel files. PI-produced SPICE files are often a result of science data analysis; for instance, improvement in instrument pointing based on interpretation of what the sensor saw or new estimates of a target body's size, shape, and orientation.

The SPICE data sets are normally made available to all project members, whether located at the mission operations center(s) or at science team member institutions. This is often accomplished using a SPICE sever. SPICE data are usually considered non-proprietary and non-sensitive, and distribution of these products (and the related SPICE Toolkit software) is not limited by U.S. Government ITAR rules.

The principal advantage of using SPICE is that the Mars Scout PI gets considerable well-tested planning and data analysis functionality for very modest cost. Also, it's possible the flight team staff needing access to ancillary data may already be familiar with SPICE from previous work. Additionally, SPICE is the usual means for archiving ancillary data in NASA's Planetary Data System; so use of SPICE up front will facilitate meeting archive requirements and supporting space science community data analysis programs for years to come.

A collection of SPICE tutorial packages--available as mostly M.S. Office PowerPoint documents--may be obtained using anonymous ftp to the NAIF server:

ftp://naif.jpl.nasa.gov/pub/naif/toolkit_docs/Tutorials/office/individual_docs/

More information about NAIF and the SPICE system can be obtained from the NAIF Manager at the Jet Propulsion Laboratory in Pasadena, CA: Charles Acton

charles.acton@jpl.nasa.gov or (818) 354-3869